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Climate Change Impacts on Wildlife Protected Areas in Southern Africa: a Bibliometric Analysis

Abstract. The article examines how climate change has impacted wildlife-protected areas in Southern Africa in the context of tourism development. Protected areas are known as preferred destinations for nature-loving tourists. Using a systematic review and bibliometric analysis the authors identify symptoms of climate change in Southern Africa's wildlife-protected areas and adaptation strategies for resilient destinations. Some of the key effects of climate change identified in the analysis include species reduction, human-wildlife conflicts, habitat quality and infrastructure modification and social impacts. The authors establish at what levels changing climatic conditions in protected areas affect conservation and tourism processes in protected areas thus contributing to the body of knowledge on wildlife-human interactions, survival strategies of community members and interactions between community members and conservation organizations. The synthesized data can be used in future studies to focus on climate-proofing protected areas and surrounding communities, can help social enterprises and conservation groups to improve community resilience against climate change and inform conservation ecosystem-based adaptation strategies.

Keywords: climate change, protected areas, wildlife, PRISMA, bibliometric analysis, Africa

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1. Introduction

Climate change and climate variability are imminent threats to the existence of nature and associated wildlife, tourism sites and community livelihoods (Chikodzi et al., 2022; Dube & Nhamo, 2020a). Studies show that the growth and development of tourism will continue to be hampered by the persisting climate change (Deason et al., 2022). Given the extent to which the tourism sector affects livelihoods, the

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effects of climate change cannot be ignored. The World Meteorological Organisation (WMO, 2022, p. 4) notes that "changes to the global climate are undermining the global ability to achieve sustainable development, directly impacting Sustainable Development Goals 1, 2, 3, 6, 7, 10, 13, 14 and 15". Rural economic development, especially in Africa, has been facilitated by the establishment of protected areas (PAs), which have helped to improve livelihoods of surrounding communities through the creation of employment and small business opportunities (Musavengane & Kloppers, 2020; Shereni & Saarinen, 2021).

An understanding of climate change at the local level enables PA managers and local communities to climate-proof PAs. The findings of this study will further help PAs to develop ecosystem-based adaptations (EbA), community-based adaptations (CbA), indigenous-based adaptations (IbA) and ecosystem-based disaster risk reduction (Eco-DRR) strategies. It is therefore essential to rely on collaboration and research in order to develop effective response measures to climate change (UNFCC, 2022). This explains calls to net zero future as alluded to in COP26 in Glasgow when the World Travel and Tourism Council "launched the first ever sector-wide Net Zero Roadmap for Travel & Tourism. The 'Roadmap' was developed jointly with the United Nations Environment Programme (UNEP) and [professional services and consulting company] Accenture, and was endorsed by the United Nations Framework Convention on Climate Change (UNFCCC)" (World Travel and Tourism Council, 2022, p. 22). The establishment of such a roadmap points to the relevance of the tourism sector in formulating and adopting climate response measures.

There are various studies on protected areas and climate change but there is little literature that examines climate impacts in protected areas and their effects on tourism in Southern Africa. Existing studies focus on the micro-level by analyzing individual cases. For example, Mushawemhuka et al. (2018) demonstrated the effects of increasing temperatures in Zimbabwe's Hwange National Park and called for well-ventilated and air-conditioned guest rooms and rehabilitation of the damaged terrain for easy access. Similarly, Kilungu et al. (2017) reported that fauna migration patterns have been altered by changing climatic conditions at the Serengeti National Park in Tanzania.

Therefore the purpose of the following study is to provide a systematic review of studies that examine impacts of climate change in Southern African PAs to enhance tourism development and livelihoods of communities that depend on tourism. The study contributes to the ongoing discussion about climate change mitigation and adaptation measures that are required to facilitate conservation and tourism development in PAs. Despite calls by governments and NGOs, there have not been that specifically investigate impacts of climate change that are unique to PAs (Dube et al., 2022).

2. Literature Review

According to WTTC (2022 p. 4), before the COVID-19 pandemic the tourism sector created 333 million direct and indirect jobs and contributed about US$9.6 trillion to the global GDP (10.3%). The relevance of the tourism sector in global development discourse in the context of climate mitigation is evidenced in the Millennium Development Goals (MDGs) for 2015 and the 2030 UN Sustainable Development Goals (Siakwah et al., 2020). During the pandemic, protected areas were the most preferred destinations for tourists because of their uncontaminated environments (Gabriel-Campos et al., 2021). However, protected areas are increasingly affected by climate change impacts.

In addition to being safe havens for biodiversity, protected areas provide extrinsic value to human livelihoods (Buckley et al., 2019). Tourism is regarded as a management tool for successful conservation in protected areas (Dudley, 2008). Tourism in PAs can contribute to biodiversity conservation through raising awareness and nature investment (Leung et al., 2018). As pointed out by Harris et al. (2021), PAs provide health benefits to tourists, in particular those suffering from stress, depression and lack of happiness. However, as Zhong et al. (2020) and Snyman (2012) note, if mismanaged, tourism can lead to socioeconomic and environmental challenges, such as social conflict and biodiversity loss. At the same time, tourism production and consumption can be disturbed by exogenous factors, such as climate change (Chikodzi et al., 2022). Consequently, what is required are sustainable tourism approaches that strike a balance between the needs of the economy, society and the environment (Hall et al., 2015). For example, Zhang et al. (2022, p. 1) reported that the sustainability of the Qinghai Lake Nature Reserve in China is "intermediate, with the sustainability of its social system being better than that of the environmental system".

Ndlovu, Matipano and Miliyasi (2021) argued that the effectiveness of conserving diversity will continue to be challenged by a myriad of factors, chief amongst them climate change, pandemics, political instability and global economic recessions. Similarly, Brashares et al. (2011) pointed out that during upheavals, local people who reside in communities located in the vicinity of PAs in tropical ecosystems tend to revert to illegal wildlife harvesting and fishing, which becomes the immediate resilient *modus operandi* and is used to hedge against economic challenges.

Protected areas also play an important role in Southern Africa, which is well documented. For example, national parks in the region attract a lot of foreign tourists interested in trophy hunting and photographic tourism (Lindsey et al., 2020). PAs are also supported by the global donor community (Lindsey et al., 2020).

Like other parts of the world, natural resources for outdoor tourism in Southern African are seriously threatened by climate variability and change (Dube & Nhamo, 2020b). Some parts of the region are experiencing heatwaves, droughts and floods due to climate change (Nhamo & Chapungu, 2021). These effects of climatic changes have affected tourism operations across all tourism sub-sectors (Thuiller et al., 2006). Cyclone Freddy and Cyclone Idai are the latest devastating phenomena that struck Southern Africa. It is therefore not surprising that the problem of climate change has been the subject of much research. A search of scholarship databases, conducted in November 2022, for the keywords 'climate change and tourism' returned 1,860,000 documents on Google Scholar, 731 in the Annals Journal of Tourism, 1033 in the Tourism Management Journal and 597 in the Journal of Travel Research. A search for 'climate change, tourism, protected areas and Africa' yielded 17,300, 77, 89 and 62 results, respectively.

3. Materials and Methods

3.1. Bibliometric Analysis

Published studies investigating the impact of climate change on tourism in PAs were obtained from the Clarivate Web of Science (WoS) Core collection. The WoS database is a verifiable source of high-quality, standardized, inclusive and reliable academic information (Li et al., 2010). The data were collected on November 7, 2022, using the WoS search engine. Data query was directed to 'All fields', i.e. the publication title, author details, abstract content, keywords, affiliations and full content. The first search string — 'Protected Areas AND Climate change AND Tourism' — yielded 429 documents. Since the study was only interested in Southern Africa, filters per region/country were applied. The database included 40 documents referring to all Southern African countries: South Africa (22), Zimbabwe (4), Botswana (5), Namibia (2), Mozambique (1), Malawi (1) and Tanzania (5). The second search on all fields — 'Parks, climate change and tourism' returned 549 documents, of which 73 related to Southern Africa: South Africa (56), Botswana (9), Zimbabwe (2), Namibia (3), Malawi (1), Mozambique (1) and Zambia (1). Only articles published in English were taken into consideration.

After excluding documents that did not feature all three themes, i.e. climate change, tourism and protected areas/parks, only 47 publications remained, six of which were duplicates. The purpose of the final selection was to identify articles

that analyze climate change impacts in Pas. There were 28 such articles, which were read in full to identify specific topics and common themes.

A plain text file of each article was saved to enable bibliometric analysis. The files were processed using the vosviewer software (version 1.6.18) to enable the graphic presentation of bibliometric results.

3.2. Data Analysis

To showcase the impact of climate change in Southern Africa, the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was employed. PRISMA improves transparency of systematic reviews by (i) identifying relevant articles, (ii) screening based on the area of focus, (iii) ensuring eligibility (Shamseer et al., 2015; Mkhongi & Walter, 2022). Themes present in the articles (Table 1) were derived deductively.

Table 1. List of articles included in the study

#	Author	Country/Region of study
1	Coldrey & Turpie (2020)	South Africa
2	Melville et al. (2021)	South Africa
3	Jamaliah et al. (2021)	South Africa
4	John et.al. (2020)	Tanzania
5	Kija et al. (2020)	Tanzania
6	Musakwa et al. (2020)	Zimbabwe
7	Searle et al. (2022)	Botswana and Zimbabwe
8	Botha et al. (2021)	Tanzania
9	Santangeli et al. (2018)	Namibia
10	Egoh et al. (2012)	Africa
11	Mudzengi et al. (2021)	Zimbabwe
12	Utete (2020)	Zimbabwe
13	Lindsey et al. (2013)	Namibia
14	Bennitt et al. (2019)	Botswana
15	Sianga & Fynn (2017)	Botswana
16	Dube & Nhamo (2020b)	South Africa
17	Mushawemhuka, Rogerson & Saarinen. (2018)	Zimbabwe
18	Mushawemhuka, Fitchett & Hoogendoorn	Zimbabwe
19	Kilungu et al. (2019)	Tanzania
20	Lwoga & Asubisye (2018)	Tanzania
21	Coldrey et al. (2022)	South Africa

#	Author	Country/Region of study
22	Mabibibi et al. (2021)	South Africa
23	Smith & Fitchett (2020)	South Africa
24	Mathivha et al. (2017)	South Africa
25	Humphrey et al. (2022)	Namibia
26	Botha et al. (2021)	Tanzania
27	Pant et al. (2020)	Africa
28	Kosamu et al. (2012)	Malawi

Source: Authors

4. Results and Discussions

4.1. Network Visualization

A total of 1209 keywords associated with the impact of climate change on protected areas in Southern Africa were identified in the articles, of which 48 were found to occur at least five times. Figure 1 shows links between climate change, tourism and conservation in protected area. . The strength of links between these keywords was auto-calculated by vosviewer based on the number links. "The strength of a link is an attribute of a link represented by a positive numerical value. The higher the value, the stronger the link" (Mkhongi & Musakwa, 2022, p. 238). Table 2 shows 15 keywords with the greatest link strength.

Table 2. Occurrences of keywords and the strength of links between them

#	Keyword	Occurrences	Total link strength
1	Climate change	48	81
2	Conservation	38	67
3	Climate change	30	60
4	Protected areas	27	52
5	Adaptation	16	45
6	Vulnerability	18	45
7	Management	23	44
8	Impacts	15	38
9	National parks	13	35
10	Perceptions	11	35
11	Tourism	11	35
12	Biodiversity	17	32

#	Keyword	Occurrences	Total link strength
13	Africa	12	31
14	Patterns	14	20
15	Impact	12	18

Source: Authors

Based on these 15 keywords, the VOSviewer system categorised them into four clusters, each marked by a different colour. A cluster is a group of related keywords associated with a common theme. The bigger the cluster, the greater the strength of the keywords (Figure 1).

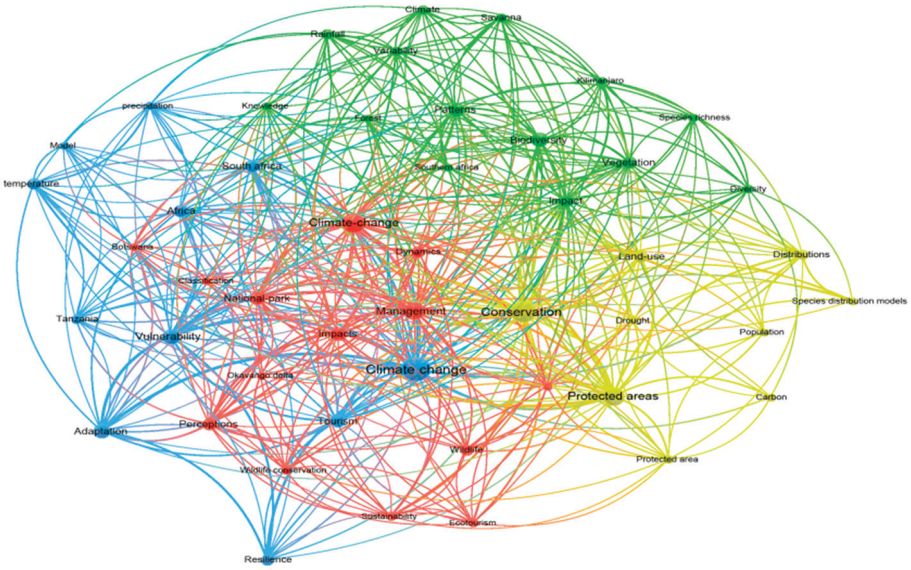

Figure 1. A network of links between keywords appearing in the articles examining the impact of climate change on protected areas in Southern Africa; colours denote clusters of closely related keywords.
Source: Authors

The big blue cluster (*climate change and sustainability of protected areas*) contains 14 items: Botswana, classification, climate change-community, dynamics, ecotourism, impacts, management, national park, Okavango delta, perceptions, sustainability, wildlife and wildlife conservation. All these items refer to the sustainability of PAs, which can be achieved through actions that can climate-proof wildlife and communities. For example, positive attitudes of community members to the environment can reduce the anthropogenic causes of climate change. The effects of climate change can also be mitigated by promoting ecotourism and ecosystem adaptation (EbA) measures introduced by PAs and surrounding communities.

The red cluster (*climate change and species diversification*) contains 14 items: biodiversity, climate, diversity, forest, impact, Kilimanjaro, knowledge, patterns, rainfall, savanna, Southern Africa, species richness, variability, and vegetation. The items in this cluster point out that rainfall patterns affect species diversity in PAs. Weather and climate variability continue to shock PAs ecosystems and threaten the survival of other fauna and flora. The depletion of some species is having a negative impact on biodiversity in PAs. On the positive side, large forest areas in Southern African PAs have a great capacity for carbon sequestration. However, the richness and diversity of these forests heavily depend on favourable climatic factors.

The small blue cluster (*climate change adaptation and resilience of PAs and local communities*) contains 11 items: adaptation, Africa, climate change, model, precipitation, resilience, South Africa, Tanzania, temperature, tourism and vulnerability. The items in this cluster point to the need for sustainable climate adaptation models in PAs to climate-proof them. Climate change knows no boundary; even PAs considered to be strong are weakened while the already vulnerable wildlife and people are faced with the prospect of elimination by the law of nature. Climate-proofing vulnerable communities and wildlife in PAs is essential in the ever-warming environments associated with erratic precipitation.

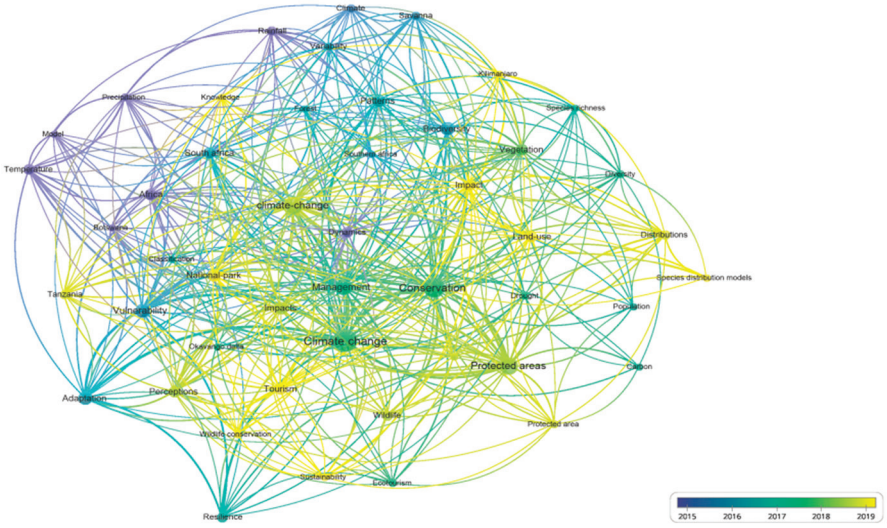

Figure 2. A 5-year trend in research concerning climate change on protected areas in Southern Africa
Source: Authors

The yellow cluster (*climate change impacts on land*) contains 9 items: carbon, conservation, distributions, drought, land use, population, protected areas and

species distribution models. These items show the relationship between space and species enrichment during climate change. Wildlife populations are greatly affected when climatic shocks and stressors, such as droughts, happen in their habitats. This leads to species depletion in PAs.

The past, current and emerging themes associated with the impacts of climate change on protected areas are shown in Figure 2, where different colours represent the publication year of articles in which the keywords appeared. Awareness of all these themes should help PA managers and researchers in developing solutions and strategies to counteract the impacts of climate change.

4.2. PRISMA and Meta-analyses of Climate Change Impacts on Protected Areas

To support the data shown in Figure 1, the following section provides a closer look at data obtained from articles listed in Table 1.

4.3. A Fall in Occupancy of Accommodation Establishments and Tourist Visits

There is an agreement among the studies that the continual increase in temperatures threatens the visitation of PAs. In their modelling study, Coldrey and Turpie (2020) reported a correlation between occupancy of tourist accommodation establishments and rainfall. The study revealed that growing temperatures discourage visitors from visiting South Africa's national parks. According to Mushawemhuka et al. (2018), climate change was the main cause of the decline in the number of visitors at national parks in Zimbabwe. Based on their models, Coldrey and Turpie (2020) made an astounding prediction that visitation at most South African national parks will decline by 2050. In preparation for such scenarios, it is necessary to develop adaptive and resilience strategies to mitigate the effects that could lead to the loss of tourists at the PAs. Jamaliah et al. (2021) argue for the need to implement technical measures such as earth dams to store water for agriculture and animals. Other proposed measures include the use of rainwater harvesting techniques, solar systems and natural light at hotel facilities in the PAs (Mushawemhuka et al., 2022).

Mudzengi et al. (2021) reported that trophy hunting in Zimbabwe was directly affected by climate change thereby negatively impacting the livelihoods of local communities. Lindsey et al. (2013) projected that wildlife would continue to have a high economic value compared to livestock during challenging climate change periods characterised by environments with more climate stressors.

4.4. Decline in Species Ddiversity and Species' Adaptation

Climate change influences many species in protected areas. Megafauna are particularly susceptible to climate change because of their weak genetic capacity to adapt to changing environments (Melville et al., 2021). John et al. (2020) predict that approximately 70% of forests (thickets) in Tanzania will have disappeared by 2085. This will be exacerbated by a high demand for biofuels. Owing to poor pollination and seed dispersal, forest fragmentation will further negatively affect riparian zones, which are essential for the movement of wildlife. This is particularly important for PAs, which depend on wildlife corridors.

Melville et al. (2021) point out that animals move from one place to another in search of food. Bennitt et al. (2019) note that buffer zones help wildlife to adapt to climate change. In their study, the authors observed that non-selective grazers, such as buffalo, moved from floodplains to riparian woodlands. John et al. (2020) argue that fauna's natural resilience to climate change is strengthened by forest connectivity. However, when megafauna moves to locations with water they tend to destroy important ecosystems characterised by a high capacity for carbon sequestration, such as mopane and acacia woodlands (Musakwa et al., 2020). To counteract the effects of climate, it is often necessary to implement intervention measures; Bennitt et al. (2019) mention the example of Sabie Game Reserve in South Africa, where hippopotami (*Hippopotamus amphibious*) were relocated because of drought to preserve them.

4.5. Human-wildlife Conflicts

Owing to dwindling habitats and declining resources as a result of climate change, conflicts between humans and wildlife are becoming more frequent. For example, in Botswana, predators and other species of megafauna, like buffalo and elephants, have expanded their ranges closer to human settlements due to flooding (Bennitt et al., 2019). Similar incidents of wildlife encroachment in human spaces due to climate-induced exogenous factors are also reported in Zimbabwe (Mushawemhuka et al., 2018). To mitigate human-wildlife conflicts during drought Gonarezhou Conservation Trust (GCT) in Zimbabwe allows local communities to access some common natural resources in the park, i.e. grass for livestock (Musakwa et al., 2020). The GCT also permits local communities to harvest natural vegetables, i.e. pigweed/mowa (*Amaranthus retroflexus*). Such practices are important in building good relations between PAs and locals, who can see themselves as co-owners of these resources. Nevertheless, Musakwa et al. (2020) reported that poaching activities tend to increase as a result of the abandonment of agricultural activities by smallholder farmers residing closer to PAs. Botha et al. (2021) agree that a shortage of resources, particularly water, threatens the communities' food supply.

Consequently, Tanzanian communities near Ngorongoro Crater prefer to breed sheep rather than cattle and goats as sheep require less feeding.

4.6. Habitat Quality and Infrastructure Deterioration

Climate change alters habitats and damages infrastructure in communities. Water reserves (i.e. dams) are directly affected by climate change. Utete (2020) reported that climate change reduces the availability of potable water in Zimbabwe, thereby threatening biodiversity. Furthermore, climate change is also altering water systems in PAs as a result of changing soil nutrient content and other factors (Mudzengi et al., 2021). According to Musakwa et al. (2020), the shortage of water for wildlife consumption in PAs is exacerbated by the need to maintain natural ecosystems. In an effort to preserve self-regulated ecosystems, the Gonarezhou National Park was against building artificial pans but has decided to allow the artificial pumping of water for animals. Pant et al. (2020) observed that as a result of climate change wetlands in PAs have dried up causing rhinoceros to lose their habitat. At Sabi Game Reserve in South Africa, which was affected by drought, there was a case of an elephant digging up water pipes to get to water the incurring of repair costs (Smith & Fitchett, 2020).

The pressures exerted on natural systems due to ecological changes are enormous. Some of these changes identified by Coldrey et al. (2022) include habitat change, resource pressure, infrastructure at risk and reduction in tourism demand. Furthermore, studies have shown that because of climate change activities of local communities have a direct impact on wildlife. For instance, stream bank cultivation undertaken by communities around Gonarezhou National Park is leading to soil erosion, which disrupts aquatic systems (Musakwa et al., 2020). Changing climatic elements are also causing a decline in ecosystem quality of Tanzania's Greater Serengeti (Kija et al., 2020). Santangeli et al. (2018), who studied the effects of climate-driven environmental variation and land-use on body condition of vulture nestlings in savannah landscapes emphasised the need to assist local communities in conservation projects that directly influence their livelihoods to sustain the protected areas. Similarly, Mabibibi et al. (2022) report projects undertaken around Kruger National Park (KNP) to prevent the extinction of some tree species because of drought, which involve planting indigenous trees around the park to preserve biodiversity and facilitate carbon sequestration.

Droughts, apart from causing water shortages, lead to the spread of diseases in PAs. Dube and Nhamo (2020a) reported that due to extreme temperatures experienced between 2014 and 2017, the population of rodents increased in the KNP. This resulted in the death of two elephants from the encephalomyocarditis virus spread by rodents. Similarly, laughing doves were affected by a *paramyxovirus* spread by

pigeons whose populations increased due to climatic changes, thereby negatively affecting avitourism (bird watching) (Dube et al., 2022).

4.7. Climate Change Social Impacts in and around PAs

The discussion so far has highlighted several negative challenges of climate change in and around PAs. Nevertheless, climate change has also positive effects on PAs and their surroundings. For example, Lwoga and Asubisye (2018) found that drought in Tanzania led to greater unity among community groups, which started to cooperate with a view to finding climate change adaptation measures. Similarly, Kilungu et al. (2019) found out that as a result of increasing temperatures mountain sickness, landslides and rock falls were significantly reduced in and nearby Mt Kilimanjaro in Tanzania. In addition, new vegetation and flowers grew at the feet of Mt Kilimanjaro, creating beautiful scenery for tourists. As a result of changes in land cover, sightseeing opportunities were improved, particularly, the waterfall. Since the snow is slowly disappearing, there is a new trend for 'last chance tourism' associated with viewing ice in Mt Kilimanjaro. Last chance tourism is referred to as travelling to a destination before it 'disappears' (D'Souza et al., 2023).

5. Conclusion

The purpose of the study was to identify the impacts of climate change on protected areas in Southern Africa in the context of conservation and tourism. The studies reviewed in the article report various adaptation measures that can be adopted by communities living around PAs as well as those already implemented by conservation authorities. The main themes identified in the analysis include a decline in the number of species, human-wildlife conflicts, habitat quality and infrastructure deterioration and social impacts of climate change.

Study limitations and future study recommendations

The study was only based on studies indexed in the Web of Science, which means it did not include other, potentially useful findings from other publications.

The study did not include quantitative analysis, which can be used in future research to triangulate qualitative findings.

The study focused Southern Africa and not did not include all countries in this region owing to article availability on the Web of Science.

The authors recommend future studies that focus on climate adaptation meas-

ures promoting sustainable conservation within PAs and surrounding communities. These may include approaches involving ecosystem-based adaptations (EbA), indigenous-based adaptations (IbA) and community-based adaptations (CbA).

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Wpływ zmian klimatycznych na obszary chronione w Afryce Południowej: analiza bibliometryczna

Streszczenie. Celem artykułu jest przegląd badań dotyczących wpływu zmian klimatycznych na obszary chronione w Afryce Południowej w kontekście rozwoju turystyki. Obszary chronione są preferowanymi celami wyjazdowymi dla amatorów turystyki przyrodniczej. W wyniku analizy bibliometrycznej autorzy identyfikują skutki zmian klimatycznych na obszarach chronionych w Afryce Południowej oraz strategie adaptacyjne dla miejsc recepcji turystycznej, które umożliwią im dalsze funkcjonowanie. Do najczęściej wymienianych skutków zmian klimatycznych opisanych w anali-

zowanych badaniach należą redukcja gatunków, konflikty między ludźmi a dziką przyrodą, zmiany w jakości siedlisk i infrastruktury oraz różne skutki społeczne. Autorzy wskazują, na jakim poziomie zmieniające się warunki klimatyczne na obszarach chronionych wpływają na procesy ochrony przyrody i lokalną turystykę; w ten sposób przyczyniają się do rozwoju wiedzy na temat interakcji między dziką przyrodą a człowiekiem, strategii przetrwania stosowanych przez społeczności lokalne oraz interakcji pomiędzy tymi społecznościami a organizacjami zajmującymi się ochroną przyrody. Przedstawione syntetycznie dane mogą być wykorzystane w przyszłych badaniach na temat sposobów zwiększania odporności obszarów chronionych i otaczających je społeczności na skutki zmian klimatycznych; mogą też pomóc organizacjom społecznym i grupom zajmującym się ochroną środowiska w poprawie odporności społeczności lokalnych na skutki zmian klimatycznych oraz w informowaniu o strategiach adaptacyjnych opartych na ochronie miejscowych ekosystemów.

Słowa kluczowe: zmiany klimatyczne, obszary chronione, dzika przyroda, PRISMA, analiza bibliometryczna, Afryka

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